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19 ABSTRACT (Continue on reverse if necessary and identify by block number) Thin films of BiSrCaCuO superconductor have been made by rf magnetron sputtering onto sapphire and MgO substrates. The use of MgO substrates produced better films. Good tunnel junctions were fabricated using YBa ₂ Cu ₃ O ₇ films with Pb counterelectrodes. No gap was seen for the YBCO film. Critical field anisotropy was studied in single crystals of YBCO and NdBa ₂ Cu ₃ O ₇ . Measurements of the Fermi-liquid effects in Ga and V were completed.					
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I. Research Objectives

AFOSR-TR- 89 - 1241

The objectives of the research under this grant were as follows:

- a. Synthesize high transition temperature superconducting materials potentially useful in superconducting electronics.
- b. Characterize the physical and chemical properties of the materials and their surfaces.
- c. Form tunnel junctions on thin films of these materials and investigate their properties.
- d. Make spin-polarized and electron-phonon spectroscopy measurements on superconducting thin films.
- e. Evolve practical theories to explain the properties of the superconducting materials and tunnel junctions.
- f. Make epitaxial films of the superconductors on crystal substrates to improve their characteristics.
- g. Explore superconductor-insulator and superconductor-superconductor composite layered structures.
- h. Form artificial tunnel barriers of refractory insulators compatible with high temperature superconductors.
- i. Compare results with basic theory including Fermi liquid effects.
- j. Explore promising unusual materials.

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II. Status of Research Effort

The research effort of the past year has been concentrated on measuring fundamental properties of high transition temperature superconducting oxides. Previously-begun work on Fermi liquid effects in conventional superconductors was successfully completed.

1. Sputtered Bi-Sr-Ca-Cu-O thin films.

Thin films of the "BSCCO" superconductor have been made by rf magnetron sputtering. Because of a report of a superconducting BSCCO material containing Al,¹ we chose to explore the use of sapphire substrates. Work on YBCO material had indicated that diffusion of Al from these substrates was detrimental to the superconductivity of that material. Our sputtering apparatus allows upward sputtering, so the targets do not have to be mechanically stable; even unreacted powder targets can be used. However, we found our best results were obtained with reacted and pressed targets. The expected tolerance for Al was not found in our films. Our best films had good onset temperatures, about 90 K, but resistance of zero was obtained only at 65 K. Better films were obtained on MgO substrates. We plan to explore rapid thermal annealing techniques and deposition onto hot (600°C) substrates. The availability of an RBS facility at MIT has been very helpful in evaluating the films.

2. Tunnel junctions on YBCO films.

We have made tunnel junctions with Pb counter electrodes on superconducting YBCO thin films. The YBCO film surfaces were oxidized by heating in an O_2 atmosphere, after which a thin Al_2O_3 barrier was deposited in situ. Good quality junctions were obtained; however, only the Pb gap was observable in the conductance data. No gap due to the YBCO was seen.

3. Anisotropy of H_{c2}

The critical magnetic field H_{c2} of $YBa_2Cu_3O_7$ and $NdBa_2Cu_3O_7$ single crystals has been measured as a function of temperature and crystal orientation in fields up to 31.5 tesla. The critical field along the a-b plane is approximately 4 times that perpendicular to the a-b plane. The measurements imply coherence lengths of about 25 Å in the a-b plane and 7 Å along the c-axis. The temperature dependence of H_{c2}^{\perp} has an unusual curvature which may imply very weak pinning, perhaps limiting the critical current in very well ordered materials.

4. Fermi-liquid effects in Ga and V.

The spin-polarized tunneling² study of Fermi-liquid effects in Ga and V has been completed. The measurements agree well with theoretical expectations. The antisymmetric Fermi-liquid parameter in amorphous Ga is about 0.8, the largest measured for metals. The large value is due to the strong electron-phonon coupling in this material. In V, on the other hand, this parameter is about zero, showing the expected influence of spin

fluctuations in this transition metal. The results of this study are being prepared for publication.

¹C.W. Chu, J. Bechtold, L. Gao, P.H. Hor, Z.J. Huang, R.L. Meng, Y.Y. Sun, Y.Q. Wang, and Y.Y. Xue, Phys. Rev. Lett. 60, 941 (1988).

²P.M. Tedrow, J.T. Kucera, D. Rainer, and T.P. Orlando, Phys. Rev. Lett. 52, 1637 (1984).

III. List of Publications

J.S. Moodera, P.M. Tedrow, and J.E. Tkaczyk
High Magnetic Field Study of Superconducting $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$
Phys. Rev. B 36, 8329 (1987)

J.S. Moodera, R. Meservey, J.E. Tkaczyk, C.X. Hao, G.A. Gibson,
and P.M. Tedrow
Critical Magnetic Field Anisotropy in Single Crystal $\text{YBa}_2\text{Cu}_3\text{O}_7$,
Phys. Rev. B 32, 619 (1988).

G. Gibson, J.S. Moodera, R. Meservey, and P.M. Tedrow
Effect of Growth, Morphology, Layering and Dimensional Cross-over
on H_{c2} of Transition Metal Nitrides
Phys. Rev. B (to be submitted).

G. Gibson, R. Meservey, and P.M. Tedrow
Fermi-liquid Renormalization of H_{c2} of Vanadium and Gallium Thin Films
Phys. Rev. B (to be submitted).

J.S. Moodera, J.E. Tkaczyk, and P.M. Tedrow
High Magnetic Field Studies of $\text{YBa}_2\text{Cu}_3\text{O}_7$ and $\text{NdBa}_2\text{Cu}_3\text{O}_7$ Single Crystals
1988 Applied Superconductivity Conference.

A. Kussmaul, G. Roesler, J.E. Tkaczyk, J.S. Moodera, X. Hao,
G.A. Gibson, R. Meservey, and P.M. Tedrow
rf-Magnetron Sputtering of Bi-Sr-Ca-Cu-O Thin Films
1988 Applied Superconductivity Conference.

IV. List of Professional Personnel

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Dr. J.S. Moodera

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G.A. Gibson (received Ph.D. Sept. 88)
J.E. Tkaczyk (received Ph.D. Sept. 88)
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